Collaborative Social and Medical Service System

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ABSTRACT

This paper describes the Collaborative Social and Medical Services System, a robust information infrastructure for integrated social and medical care. The Collaborative Social and Medical Services System design and architecture address the primary goals of creating a readily extensible social and ambulatory care system. Our initial step toward reaching this goal is the delivery of an application supporting the operations of the Baylor Teen Health Clinics. This paper discusses our protoype experiences, system architecture, components, and the standards we are addressing.

INTRODUCTION

Information required for patient care has traditionally been assembled in a paper chart format from a variety of sources by a team of providers including physicians, nurses, therapists and clerical staff. A recent review by the Institute of Medicine highlights the limitations and resultant impediments to efficient and effective health care created by the perpetuation of a paper-based record as the primary medical information repository[1]. Despite its limitations, the paper-based record provides the current communication and information management "workstation" for health care providers.

Information system applications that support technical services (diagnostic imaging, laboratory, etc.) and nursing have been available for several years and are being improved or supplemented by new entries into the field. To date, clinical workstation applications and computer-based patient records have focused on text and numeric data, with some recent systems beginning to incorporate static images[2,3]. Overall, these applications have demonstrably improved the efficiency of health care delivery when appropriately fitted to the target institutions' information systems strategy. However, many difficulties have impeded the common use of applications that address the requirements of physicians and other direct providers of health care. Such difficulties include the complexity of the functional requirements and the mobility of the user population, to name only a few. Nevertheless, computerization of clinical data is essential to containing or reducing cost while maintaining quality.

Clinical medicine is not the only discipline that may benefit from the application of computer-based technologies. There is an increasing need in our society today to have integrated systems of health care, community development, family services, and job training as a support structure for the poor and the disadvantaged.

To address the information management needs of such collaborative services, we are designing and implementing the Collaborative Social and Medical Services System (CSMSS). The CSMSS is a new health and human services system designed to address the general domains of social and primary clinical care as well several long term strategic issues which include; the need for an application architecture that is capable of extension and adaptation to changes in technology (e.g., multimedia, human-computer interfaces such as voice-to-text) and the need for a data model capable of supporting "generic" ambulatory services for collaborative medical and social services.

BAYLOR TEEN HEALTH CLINIC DOMAIN

We are creating an architecture and application framework to support integrated social services and primary

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medical care with the Teen Health Clinics (THC) of the Baylor College of Medicine as an initial test of our systems architecture[4]. These clinics are staffed through the collaborative efforts of the Department of Obstetrics and Gynecology at Baylor, the Population Program within the College, and the Harris County Hospital District (HCHD), the fourth largest health services agency in the nation.

The target population includes adolescent boys and girls 19 years of age and under, who reside primarily in the Houston, Texas inner city. Patients receive services such as family planning, sexually transmitted disease screening and treatment, perinatal care, case management (i.e., social work), counseling, and support services. Adolescents may receive services at any clinic site at no cost to the adolescent or family members.

Current management practices, which are heavily constrained by the use of paper based records, result in inefficiency of care due to delayed access to information or the inability to conduct research on THC's patient population. According to the statistics developed by the Clinic staff, the inability to effectively coordinate the various patient care priorities and schedules is a significant barrier to good care. For example, a counselor providing case management will often need to balance school schedules, clinic visits, well baby follow-up, and the Best Friends Program for a new mother. In addition, the lack of ready access to patient information impairs clinical and social service staff ability to provide continuity of care. In fact, some dropout from the program is attributable to the difficulty in coordinating the records and schedules for clinics and other programs provided by the THCs. The paper charting system used by the THCs today inhibits any outcomes, utilization review, and quality improvement research based on large volumes of patient data. There is no way to measure the impact of having the ability to conduct these types of research would have on their abilities to provide better overall care.

Beyond the current needs of the THCs it is essential that one basic architecture and data model also address requirements which may be imposed on this system in the future as it is applied to other clinical and social services domains.

Changing demands arise from an inability to predict patterns of health care delivery, the evolving nature of the integration of health care and social services, the transitory nature of emerging information systems standards, and the rapidly expanding volume and types of information that can reasonably be expected to become part of the patient record. All of these issues mandate an architecture capable of adapting to these challenges.

THE VIRTUAL CHART SYSTEM - A PROTOTYPE

We constructed a "proof of concept" prototype, called the Virtual Chart System (VCS) to aid in refining project specifications in light of the THC requirements and our long term strategic goals[5,6].

The prototype was constructed using the Virtual Notebook System (VNS) technology for collaborative work developed at Baylor College of Medicine[7].

We found the VNS "notebook" metaphor and underlying system architecture are fundamentally inadequate to support the development of comprehensive clinical information systems. A combination of VNS code and TCL/TK scripts were required to obtain the desired prototype application functionality[8]. We also found that the proposed system would require -

- a highly structured yet generalized data model to support clinical and social domains
- a provision for schema evolution in the database implementation strategy
- enforced structured data entry
- "write-once", read-only data entry
- an integrated facility for efficient and reliable data retrieval
- a multi-threaded server design for achieving system performance necessary to support a clinical application
- a security model capable of providing for the complex access policies necessitated by conflicting privacy and access requirements

The deficiencies noted in the prototype and subsequent reviews and comments by clinical users are substantial enough to warrant the development of a new architecture designed from the outset to support robust and highly-functional collaborative medical and social services applications.

CHARACTERISTICS OF THE CSMSS ARCHITECTURE

Data model and database

The data model must be capable of significant evolution over time without major redesign or major changes to the associated applications. For example, the support of multimedia capabilities within the patient record will allow the incorporation of more

complete and more detailed documentation of the context in which medical care and social services decisions are made. Additionally, incorporation of multimedia capabilities in the broader system design will allow support of expanded services and capabilities including educational, conferencing, and telemedicine applications using the same server infrastructure. Thus, there is a need for rapid adjustment to and design of alternative data models which may be integrated with the original model as needed. For this reason, we have chosen an Object-Oriented Data Base Management System (OODBMS) as the foundation for our server architecture[9].

Client/Server

To provide for the dynamic nature of technology evolution we have chosen to modularize our system design at a high level by defining robust interfaces that should survive these changes. The client application depends only on the protocol between the client and the server to support access to patient data[4]. Building new clients based on other platforms under new operating systems will not require changes to the server architecture. The server, likewise, can be ported without changes to clients as long as the protocol is preserved[10]. We have abstracted the services provided by the OODBMS into a virtual interface that is supported by our broker layer. This insulates our server from depending on any particular OODBMS inherently. The intent of these design decisions is to make components of our design as portable, survivable, and maintainable as possible.

Access Control

The medical care delivery setting in general, and the outpatient clinic setting in particular, demand extraordinary flexibility from any access control mechanism associated with an underlying patient record system. The reasons for this needed flexibility include the following:

- Clinics need local control of their staff rosters since personnel rosters can change dynamically for a variety of reasons. This requirement implies the need for establishing access for individuals on that roster for access appropriate to their assigned role. If role definition (job function) is also in the hands of the end user, the access control must be specified in terms understandable by the clinic system administrator (probably not the terms of internal data model components or widgets).
- The nature of health care delivery requires a preemption mechanism which gets the security mechanism "out of the way" in emergency circumstances. Accountability requires that this action be backed by an authenticated audit trail.
- The changing nature of access control policies and their inherent complexity require flexibility. Most existing access control models (e.g. ACLs, C-LISTS) have difficulty supporting certain simple access management requests[11]. For example, the request "Revoke all access to patient records for Mr. Jones" is very difficult to accomplish in an ACL-based system and the request "Revoke all access to Mr. Presley's patient record" is very difficult in a C-List-based system.

Our approach utilizes an extended access matrix model to allow flexible policy enforcement while being manageable by clinic staff[10].

Data Entry Methods

The informational needs of the THCs will necessarily change over time, establishing significant justification for any system to be adaptive to these inevitable changes. We will provide an interactive mechanism for user definition of forms for data collection to support user driven adaptation of the application over time and in response to emergent requirements. We will also provide a mechanism for controlling the sequence and conditions under which forms are presented to users, thereby allowing user driven definition of the workflow process.This process is currently controlled by manually issued standing orders.

We recognize that system acceptance and utilization depends greatly upon the ease of data entry in the system. We are investigating the potential uses of voice and handwriting recognition input technologies integrated with mobile computers to enhance data acquisition.

CSMSS COMPONENTS

All of the CSMSS components are based on object oriented software engineering methodologies. Figure 1 depicts a high level view of the architecture of the CSMSS system. The application is based on a Client-Server model and supports geographically distributed clinic operations. Communication between client and server will occur via T-1 lines for Phase I, and subsequently on higher performance communications facilities, e.g. ATM, as multimedia and conferencing features become part of the environment.

Applications running on the client workstation communicate using Microsoft's Object Linking and Embedding (OLE) 2.0 facilities, allowing "drag and

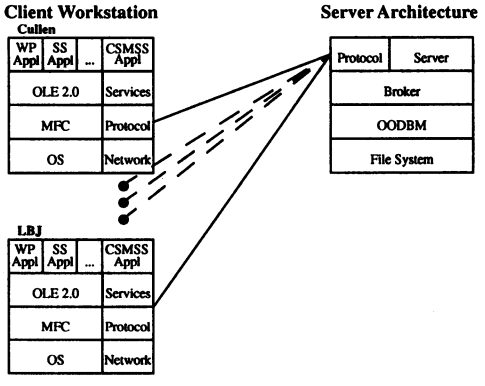

Figure 1. Collaborative Social and Medical Services System Architecture

drop" activation with highly flexible sharing of data between applications. The CSMSS Client application requests Server information through a basic services interface which generates the appropriate protocol requests to be transmitted over the network to the server.

The server receives protocol requests and translates them into service requests administered by agents. These services are cast in terms of a virtual OODBMS independent of any specific OODBMS and are mapped into requests specific to a particular OODBMS in the broker layer. The specific OODBMS supports navigation of the data model and finally makes file system requests that allow access to the text, imagery, bitmaps, and eventually digital voice and video that will comprise the electronic version of a patient-centered medical record.

STANDARDS

The CSMSS is being developed with attention to emerging standards. Adherence to systems standards will support portability and long term viability of CSMSS in the face of rapidly evolving software and hardware technologies. Provision for supporting medical messaging standards will allow effective data interchange and support integration of CSMSS within broader scale medical information contexts.

The systems standards that CSMSS will support are: ANSI C++ as our application development language, the Microsoft Foundation Classes (MFC) as our standard class library, Microsoft OLE for standard application communication and interoperability, Berkeley sockets for application access to network capabilities, Kerberos for standard authentication and encryption services[4,10].

The CSMSS will provide a Health Level 7 (HL7) interface for acquiring information from other hospital information systems. The specification operational guidelines and reminder/event notification rules will be provided using the ASTM E1460 (Arden Syntax). Finally, the data model at the core of CSMSS is based on the ANSI/HISPP MSDS JWG (IEEE P1157) for a Common Data Model[9].

CONCLUSION

Applications that address the requirements of physicians or other providers are not in common use due to the complexity of the functional requirements and the absence of a robust application infrastructure for the facilitation of the development of social and outpatient services applications. The focus of the CSMSS development activities have been twofold: first, to establish just such an infrastructure for supporting the collaborative social and medical services applications, and second, to develop a domain specific application using this infrastructure focused on supporting the activities of the THCs.

The CSMSS project schedule spans 3 years with a 3 phase development and deployment schedule. Our first phase, which we will deliver to the THCs January of 1995, will be the electronic version of the current THC's paper charting system with native interfaces to other hospital systems. Phases 2 and 3 will include the ability for the user to define data forms, multimedia capabilities and an integrated HL7 interface to other hospital information systems.

The Medical Informatics and Computing Research Program will continue to enhance, evaluate and evolve CSMSS as a foundation for exploring the development of innovative information systems across an expanding number of applications areas.

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